DOCUMENT RESUME

ED 179 416 SE 029 439

AUTHOR Friedland, James
TITLE Huntington II Simulation Program - TAG. Student Workbook, Teacher's Guide, and Resource Handbook.
INSTITUTION Digital Equipment Corp., Maynard, Mass.; State Univ. of New York, Stony Brook. Huntington Computer Project.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE May 73
GRANT NSF-GW-5883
NOTE 55p.; For related documents, see SE 029 434-440 and ED 093 644-645; Not available in hard copy due to marginal legibility of original document

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Biology; *Computer Assisted Instruction; *Conservation Education; Environment; Game Theory; Instructional Materials; Natural Resources; Population Growth; Sampling; *Science Education; Secondary Education; *Simulation; *Wildlife Management

ABSTRACT

Presented are instructions for the use of "TAG," a model for estimating animal population in a given area. The computer program asks the student to estimate the number of bass in a simulated farm pond using the technique of tagging and recovery. The objective of the simulation is to teach principles for estimating animal populations when they cannot be counted directly or when counting would disturb or harm the animals. (Author/RE)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

DIGITAL EQUIPMENT CORPORATION

education

STUDENT WORKBOOK $.30

U S DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

HUNTINGTON II Simulation Program - TAG

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Mary L. Charles
NSF
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

ED179416

SE 029 439

DIGITAL EQUIPMENT CORPORATION
EDUCATIONAL PUBLICATIONS

A partial list of the publications in the continuing series of curriculum material published by Digital for use with EduSystems and RSTS are listed below. Please inquire directly for prices on classroom quantities.

Additional publications may be obtained from:

Software Distribution Center
Digital Equipment Corporation
Maynard, Massachusetts 01754

Populution: Self teaching BASIC Workbook	$2.00
BASIC Matrix Operations, Project Solo	$1.00
Problems for Computer Mathematics	$1.25
Advanced Problems for Computer Mathematics	2.00
BASIC Application Programs	
Mathematics I	$1.00
Mathematics II	1.00
Science	1.00
Business and Social Studies	1.00
Plotting	1.00
Huntington I Application Programs	
MATHEMATICS	$2.00
TEACHER ASSISTANCE	1.00
Huntington I Simulation Programs	
BIOLOGY	$1.00
CHEMISTRY	2.00
EARTH SCIENCE	1.00
PHYSICS	2.00
SOCIAL STUDIES	1.00
Huntington II Simulation Modules	
Student Workbook	$0.30
Teacher's Guide	.30
Resource Handbook	.50
Program Paper Tape	1.00

STUDENT
MANUAL

TAG

"TAGGING AND RECOVERY" METHOD
FOR WILDLIFE POPULATION STUDY

Developed By:

James Friedland,
General Douglas MacArthur High School
Levittown, New York

Programmed By:

James Friedland
Stuart Hollander,
State University of New York
Stony Brook, New York

Support Material By:

James Friedland
Granville J. Smith, II
Northwest Regional Educational Lab
Portland, Oregon

HUNTINGTON TWO COMPUTER PROJECT

Copyright © 1973, State University of New York

14 May 1973

The work of the Huntington Two Computer Project is partially supported by the National Science Foundation, Grant GW-5883.

TAG

STUDENT MANUAL

Table of Contents

I. The *TAG* Experiment 1

II. Running the *TAG* Program 5

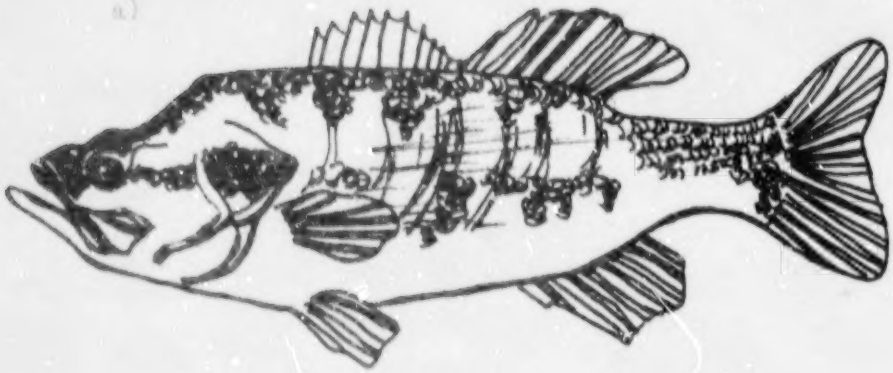
III. Preparations for *TAG* 8

I. THE *TAG* EXPERIMENT

In this computer simulation, you are faced with the problem of determining the approximate bass population in a warm-water, bass-bluegill farm pond. In a real situation, it might be possible to count all the fish directly by draining the pond or removing all the fish from the pond. In either case, many of the fish would die and the ecology of the pond would be seriously altered.

In order to obtain a reliable estimate of a fish population without harming the fish or severely altering pond ecology, scientists have developed the technique of tagging and recovery. *Tagging* is the simple process of attaching a disk-type tag or an internal anchor-type tag to a fish. Fish that are to be tagged usually come from a hatchery or are trapped. The tagged fish are released into the farm pond where they are allowed to mix with untagged fish. After time has been allowed for this mixing to occur, a sample fish is caught and inspected for the tag. After each fish is captured and examined, it is returned to the pond. Taking the sample fish from the pond is called *recovery*.

a)



b)

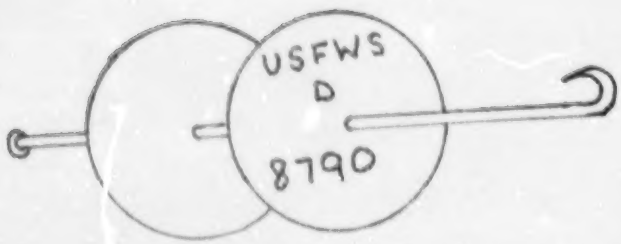


Figure 1 -- a) Large-mouthed bass; b) disk tag

How can sample-taking be used to find the total pond population? Consider the following example of a tagging and recovery experiment:

> Suppose we receive 200 tagged bass from a hatchery and release them into the pond. We wait several days for the tagged and untagged fish to mix and, after the diffusion has occurred, we take a sample of 100 fish. The sample consists of 25 *tagged* bass and 75 *untagged* bass. Now, how do we figure out how many bass are in the pond?

You could solve the problem in the following way:

> Based on your sample, 1/4 of the fish are tagged. Since there are 200 tagged fish (that's the number we put in), the total number of fish in the pond must be 4 times that number or a total of 800 fish.

If this informal solution leaves you dissatisfied, you might try a more formal approach; the following solution utilizes the concept of proportions:

$$\frac{Q \text{ (tagged fish in pond)}}{P \text{ (total number of fish in pond)}} = \frac{M \text{ (tagged fish in sample)}}{N \text{ (number of fish in sample)}}$$

or $$P = Q \times \frac{N}{M}$$

For our example,

$Q = 200$

$N = 100$

$M = 25$

$$\therefore \quad P = \frac{200 \times 100}{25} = 800 \text{ fish.}$$

Is this answer accurate? Yes, <u>if</u> the sample is representative of the pond composition as a whole; if the percentage of tagged fish in your sample is higher or lower than the actual percentage in the whole pond, your answer will <u>not</u> be accurate.

In order to guarantee a representative sample, it is essential that you give the tagged fish enough time to mix with the natural untagged population. In the *TAG* program, you will investigate this and other factors of sample selection.

In the next section there is a description of the *TAG* program. If you feel that you understand the tagging and recovery technique and the proportions formula, you can proceed to the *TAG* program. If you still have questions, or if the technique still seems somewhat mysterious, then you should work through the following exercise. Even if you're confident about the proportions formula, you might work out the exercise. It's easy to do, and it probably will give some insight into the more general nature of sampling problems.

Preparation Exercise: *The Bean Seed Problem*

Fill a pint container approximately one-half full of bean seeds.

1) Devise as many ways as you can for estimating the number of bean seeds in the container. For each method that you devise, compute an estimate of the number of bean seeds in the container.

2) Do you think that any of the methods which you used in (1) could be used to estimate the fish population in a farm pond without altering the ecology of the pond? Explain.

Now add 20 bean seeds that have been marked (use nail polish, paint, ink, etc.) to the bean seeds already in the container. By marking the beans, you ensure that they are the same volume and density as the original beans. Why is this important? Shake the container vigorously to mix the bean seeds.

3) Cover your eyes and draw out 20 bean seeds from the container. Use the proportions formula $Q/P = M/N$ given on page 2 to estimate the total bean-seed population in the container. (Before you can do this, you will need to define P, Q, N, and M for this problem.)

4) Repeat the procedure in (3) three more times, then find an average of the four estimated values for P.

5) Now repeat the procedure described in (3) with the following change: after the first bean seed is drawn from the container, record whether or not it is marked, then return it to the container and shake the container well. Repeat this process until the results of 15 drawings have been recorded. Now use the formula to determine the bean-seed population of the container.

6) Repeat the procedure in (5) three more times; then find an average of the four values for P.

7) Now count the number of beans in the container. Which population estimate was the most accurate?

8) In view of your answers to (3), (4), (5), and (6), discuss each of the following questions:

a) Do you think the results would have been different if the number of marked beans had been larger? smaller?

b) Compare your results with those of one of your classmates who used a container with a different shape. How do you think the shape of your container might have affected your results?

c) Suppose you had emptied the beans into a container with a surface area such as a pie tin. How would you have altered your technique for drawing out beans and shaking the container? Why? Do you think your reasoning will apply to the farm-pond problem? Discuss.

d) If you had dropped your container of beans and in the recovery of them missed a few, how great an effect do you think this would have on your results? Can you see a possible comparison between this situation and the mortality rate for tagged fish in the farm pond? Discuss.

e) A factor which does not enter into the bean problem but which is basic to the farm-pond problem is the factor of time. Discuss.

Keeping the questions and answers to this problem in mind, see how accurately you can estimate the population in the simulated farm-pond problem.

II. RUNNING THE *TAG* PROGRAM

The computer will ask you to estimate the number of bass in a simulated farm pond through the use of tagging and recovery. At the beginning of the problem the computer will ask you:

HOW MANY TAGGED BASS DO YOU WANT FROM THE HATCHERY ?

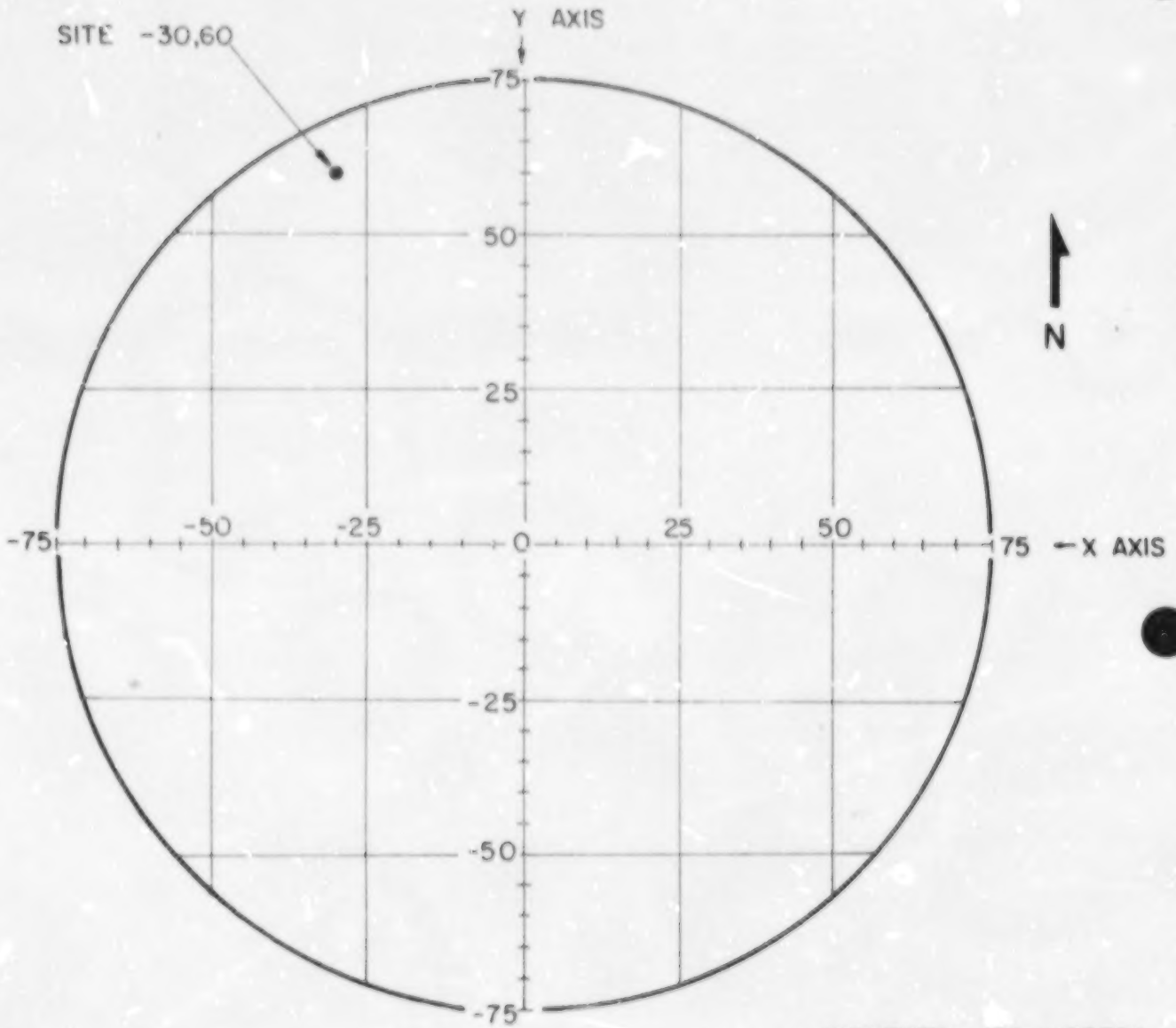
You may select any number of tagged bass up to 400, but you should attempt to disturb the ecology of the pond as little as possible. In keeping with this aim, select the lowest number of tagged bass that you think will do the job.

HOW MANY DAYS, AFTER RELEASE OF THE BASS FROM THE CENTER OF THE POND, DO YOU WANT TO SAMPLE ?

If you sample right away, all the fish will be near the center of the pond and this will give you a poor estimate of the total population. The *tagging and recovery* method requires that you leave enough time for the fish to become thoroughly mixed throughout the population; if you wait *too* long, however, some of the tagged fish will die. *TAG* allows you to sample on more than one day, but once a day has passed you cannot go back. You are allowed up to 20 different samples.

AT WHAT SITE DO YOU WANT TO SAMPLE FIRST
(REFER TO MAP IN STUDENT MANUAL FOR X AND Y COORDINATES.
ENTER AS X,Y) ?

TAG allows you to sample the fish population at any site on the surface of the pond. So that we might keep a record of where we have sampled, the pond has been mapped on graph paper, and X and Y coordinates have been placed over the map. Examine the following map.



DIAMETER: 150 METERS
APPROX. 500 FT.

COORDINATE MAP FOR FARM POND

Notice that the center of the map has the coordinates (0,0) If you want to sample to the northwest of the center of the pond, you would select the point with the coordinates (-30,60). To help you understand the system, we have labeled this point on the map. If you chose this particular site you would type "-3Ø,6Ø" in answer to this question:

```
AT WHAT SITE DO YOU WANT TO SAMPLE FIRST
(REFER TO MAP IN STUDENT MANUAL FOR X AND Y COORDINATES,
ENTER AS X,Y)  ? -3Ø,6Ø
```

You should select at least five points as sampling sites before you go to the computer. In order to get a good sample, make sure the five points are spread over the entire surface.

Next, the computer will ask:

```
HOW MANY FISH ?
```

You may sample any number of fish at this site. *TAG* assumes that you catch one fish at a time, examine it for the tag and immediately return it to the water. This means that if you catch a large number of fish, you may catch the same particular fish twice.

After you have answered these questions, *TAG* will give you a report on your catch at that station. At the end of the report it will ask:

```
ANOTHER SAMPLE ON DAY (T) (1=YES, Ø=NO) ?
```

If you answer with "1" (meaning YES), then you will be asked for a new set of site coordinates and you will be able to sample at this new site. If you answer the above question with a "Ø" (meaning NO), the computer will ask:

```
DO YOU WANT TO SAMPLE ON ANOTHER DAY (1=YES,Ø=NO) ?
```

If you answer this question with a yes, you can sample on a later day. If you answer no, the computer will give you the formula for figuring out the total population from your best samples.

The *tagging and recovery* method requires that the tagged fish be uniformly distributed throughout the pond; therefore, a good set of samples should show about the same percentage of tagged fish at each site.

After you have completed your calculations using the data sheet at the end of this manual, you should attempt to estimate the total number of *untagged* fish in the pond. You can obtain a good estimate for the number of untagged fish by averaging the results of your best samples. In general, good samples will yield individual estimates for the total population that come fairly close to agreeing. The computer will ask for this estimate:

```
ENTER YOUR ESTIMATE OF THE UNTAGGED BASS POPULATION ?
```

If your estimate is within 10% of the correct answer, the computer will reply:

YOUR ESTIMATE IS GOOD. CONGRATULATIONS.

If your estimate is between 10% and 25% of the correct answer:

YOUR ESTIMATE IS CLOSE, BUT NOT WITHIN 10 PERCENT
OF THE ACTUAL POPULATION.
EXAMINE YOUR SAMPLING STRATEGY AND TRY AGAIN.

If your estimate is not within 25% of the correct answer, the computer will type:

YOUR ESTIMATE WAS NOT WITHIN 25 PERCENT
OF THE ACTUAL POPULATION.
EXAMINE YOUR SAMPLING STRATEGY AND TRY AGAIN.

III. PREPARATIONS FOR *TAG*

There are no peculiarities in *TAG*; you should make very few errors the first time you run the program. However, collection and analysis of the data is somewhat more complicated. It is a good idea to record your data on a data sheet like the one included as the last page of this manual.

In any scientific investigation, it is usually good practice to leave as many things as possible constant. In this case it might be wise to use the same sample size throughout the experiment. (Why?) Also, for any scientific experiment, planning is essential. No scientist would ever start an investigation without planning nearly every aspect. Below is a list of things that you should plan before going to the computer to start your investigation:

1) Number of fish to be ordered from hatchery _____

2) Sites to be investigated (select at least 5)

	X	Y	coordinates
SITE A.			
SITE B.			
SITE C.			(Use map to figure coordinates)
SITE D.			
SITE E.			

3) Number of fish to be caught at each station _____

4) First day that sampling will take place _____

DATA SUMMARY SHEET

Number of tagged fish: Q = _____

DAY T	STATION X,Y	SAMPLE SIZE N	TAGGED FISH IN SAMPLE M	UNTAGGED FISH IN SAMPLE N - M	CALCULATED TOTAL POPULATION $P = \frac{N \times Q}{M}$	CALCULATED* UNTAGGED POPULATION P - Q

*Average the results of your best representative samples to get your estimate of the untagged population.

DIGITAL EQUIPMENT CORPORATION

TEACHER'S GUIDE $.30

education

HUNTINGTON II Simulation Program - TAG

DIGITAL EQUIPMENT CORPORATION
EDUCATIONAL PUBLICATIONS

A partial list of the publications in the continuing series of curriculum material published by Digital for use with EduSystems and RSTS are listed below. Please inquire directly for prices on classroom quantities.

Additional publications may be obtained from:

Software Distribution Center
Digital Equipment Corporation
Maynard, Massachusetts 01754

Populution: Self teaching BASIC Workbook	$2.00
BASIC Matrix Operations, Project Solo	$1.00
Problems for Computer Mathematics	$1.25
Advanced Problems for Computer Mathematics	2.00
BASIC Application Programs	
Mathematics I	$1.00
Mathematics II	1.00
Science	1.00
Business and Social Studies	1.00
Plotting	1.00
Huntington I Application Programs	
MATHEMATICS	$2.00
TEACHER ASSISTANCE	1.00
Huntington I Simulation Programs	
BIOLOGY	$1.00
CHEMISTRY	2.00
EARTH SCIENCE	1.00
PHYSICS	2.00
SOCIAL STUDIES	1.00
Huntington II Simulation Modules	
Student Workbook	$0.30
Teacher's Guide	.30
Resource Handbook	.50
Program Paper Tape	1.00

TEACHER
MANUAL

TAG

"TAGGING AND RECOVERY" METHOD
FOR WILDLIFE POPULATION STUDY

Developed By:

James Friedland,
General Douglas MacArthur High School
Levittown, New York

Programmed By:

James Friedland
Stuart Hollander,
State University of New York
Stony Brook, New York

Support Material By:

James Friedland
Granville J. Smith II
Northwest Regional Educational Lab
Portland, Oregon

HUNTINGTON TWO COMPUTER PROJECT

Copyright © 1973, State University of New York

14 May 1973

The work of the Huntington Two Computer Project is partially supported by the National Science Foundation, Grant GW-5883.

TAG

TEACHER MANUAL

Table of Contents

I. Basic Information about the Unit 1

II. Introduction to the *TAG* Unit 2

III. Description of the *TAG* Program 2

IV. A Successful Strategy for *TAG* 4

V. Sample Runs of *TAG* 7

VI. Plan for Using *TAG* 14

TAG

TEACHER MANUAL

I. BASIC INFORMATION ABOUT THE UNIT

Subject Area:	Biology, general science, general math
Specific Topic:	Population biology
Grade Level:	9 - 11
Coordinated Computer Program:	*TAG*
Computer Language:	BASIC
Special Language Features Used:	RANDOMIZE

Abstract: The *TAG* program provides students with an opportunity to investigate the size of a wildlife population through the technique of tagging and recovery. *TAG* uses the large-mouth bass population of a simulated farm pond as the study species.

II. INTRODUCTION TO THE *TAG* UNIT

To scientists interested in the preservation of wildlife, it is of fundamental importance to be able to know the current condition of the species they wish to aid. In most cases, they must be able to get a reliable estimate of the numbers of a particular species present before they can hope to manage or aid them. The most obvious method of determining the population is to go out and count all the animals. This is not always possible, especially if the animals exist in places which the scientists cannot reach, or if counting itself would in some way disturb or harm the animals. *TAG* teaches the student one technique that is used by the scientist to estimate the animal population in a designated area.

Most modern biology texts deal only briefly with a discussion of population problems. Generally, if population census is included at all, the presentation is brief and lacking in laboratory activities. The *TAG* unit presents the student with a detailed simulation of a real technique *(tagging and recovery)* used by scientists to estimate the size of a wildlife population.

It should also be clear that *TAG* offers the student a considerable time advantage. It is likely that an actual experiment which involves *tagging and recovery* of some species can be designed and run by the student; however, this sampling technique is characterized by the long time periods required for completing the sampling. If the student is attempting to learn good sampling techniques while the experiment is run, the completion time becomes unreasonably long. *TAG* offers the advantage of shortening this whole process.

III. DESCRIPTION OF THE *TAG* PROGRAM

The computer program in this unit asks the student to estimate the number of bass in a simulated farm pond using the technique of tagging and recovery. At the beginning of the problem, the computer asks the student to respond to the following questions:

```
HOW MANY TAGGED BASS DO YOU WANT FROM THE HATCHERY ?

HOW MANY DAYS AFTER RELEASE OF THE BASS FROM THE
CENTER OF THE POND DO YOU WANT TO SAMPLE ?

AT WHAT SITE DO YOU WANT TO SAMPLE FIRST
(REFER TO MAP IN STUDENT MANUAL FOR X AND Y COORDINATES.
ENTER AS X,Y) ?

HOW MANY FISH?
```

After these questions are answered, the computer prints the sample number (N), the number of tagged bass (M) and untagged bass (N-M) at the station (X,Y) for the day (T) requested.

The student may continue to get information for any day and station he wishes by responding to the questions:

ANOTHER SAMPLE ON DAY (T) (1=YES, Ø=NO) ?

SITE COORDINATES ?
HOW MANY FISH ?

or

DO YOU WANT TO SAMPLE ON ANOTHER DAY (1=YES, Ø=NO) ?
WHAT DAY NO. ?

AT WHAT SITE DO YOU WANT TO SAMPLE FIRST ?
HOW MANY FISH ?

When the student has stopped taking samples, the program prints out:

IF YOU HAVE SELECTED YOUR SAMPLES CAREFULLY
YOU SHOULD BE ABLE TO DETERMINE THE TOTAL
BASS POPULATION OF THE POND.

Y O U CAN USE THE FORMULA:

$$\text{TOTAL POP.} = \frac{\text{(TOTAL TAGGED FISH IN POND) X (SAMPLE SIZE)}}{\text{(NUMBER OF TAGGED FISH RECOVERED AT SITE)}}$$

DO YOU WISH TO DO THE CALCULATIONS YOURSELF (1=YES, Ø=NO) ?

If the response is negative, the computer will ask the following question:

WHICH SAMPLE DO YOU WISH TO EVALUATE FIRST (SAMPLE NUMBER) ?

The machine will then perform the calculations and print out the solution (rounded to the nearest whole integer) in the same format as used for the sampling formula. (See sample runs for examples.) The student may perform the calculations or have the machine do so for as many samples as he wishes.*

When the results for all samples have been calculated, the computer will instruct the student:

ENTER YOUR ESTIMATE OF THE UNTAGGED BASS POPULATION ?

The word UNTAGGED is important. The student must subtract the number of tagged fish from the total population. Students should be encouraged to use the DATA SUMMARY SHEET to avoid confusion.

---

*If you want your students to do their own calculations and not have the option of using the computer, you can eliminate this option from the program. See Section IV, Part G, in the *RESOURCE MANUAL* for details.

If the student's estimate is within 10% of the correct answer, the program responds:

YOUR ESTIMATE IS GOOD. CONGRATULATIONS.

If the sample is within 10% to 25%, the program prints:

YOUR ESTIMATE IS CLOSE, BUT NOT WITHIN 10% OF THE
ACTUAL POPULATION.
EXAMINE YOUR SAMPLING STRATEGY AND TRY AGAIN.

If the sample is not within 25% of the correct answer, it prints:

YOUR ESTIMATE WAS NOT WITHIN 25 PERCENT
OF THE ACTUAL POPULATION.
EXAMINE YOUR SAMPLING STRATEGY AND TRY AGAIN.

NOTE: Although *TAG* is easy to use, some confusion can result from the use of the formula required to estimate total population size. The formula gives an estimate for the total population in the pond at the time of sampling. This would also include the tagged fish as they are members of the same species. The formula also assumes that none of the tagged fish have died; this may not be true if long periods of time have elapsed since introduction of the fish.

IV. A SUCCESSFUL STRATEGY FOR *TAG*

A. Selection of Fish from the Hatchery

Since the student should be aware of the ecological advantages of tagging and recovery, he should use as few fish as possible. In general, 100 fish is more than enough to introduce into such a small pond. In reality, an ecologist would use many fewer fish.

Suggestion: Ask an interested student to continue study with *TAG* by checking the effects of using fewer fish. At what lower limit is reliability lost?

B. Selection of Days for Sampling

The fish are assumed to be introduced into the center of the pond at the beginning of Day 1. They diffuse outward toward the margins of the pond at a slow rate, determined by a diffusion constant (see Section IV in the *RESOURCE MANUAL*). The student should allow enough days for the introduced fish to randomly distribute themselves throughout the pond. If the student's samples indicate that the tagged fish are still not randomly distributed, encourage him to sample again on a later day. He can do this by responding to the following questions:

ANOTHER SAMPLE ON DAY (T) (1=YES,Ø=NO) ? Ø

DO YOU WANT TO SAMPLE ON ANOTHER DAY (1=YES,Ø=NO) ? 1

WHAT DAY NO. ?

Sampling must not be delayed too long, however, or the tagged fish will begin to die (remember the offspring of the tagged fish will not carry tags). In general, about 30 days will be required if the student wants to obtain a good distribution, since diffusion starts rapidly but slows as time goes on. Since small errors are acceptable, however, samples may be taken at an earlier time.

C. Selection of Sampling Sites

The user is allowed to sample over the entire surface of the pond. To choose a site, a student should consult the map of the pond found in the *STUDENT MANUAL*. The X and Y coordinates of the chosen location should be determined and these numbers entered into the computer in the form of (value of X), (value of Y). For example, if the student wished to sample a location with the X coordinate of -35 and a Y coordinate of 10, the number would be entered into the computer as "-35,1Ø".

Locations of sampling sites should be scattered over the entire surface of the pond, including areas near the border. Encourage your students to select at least 5 sampling sites in advance; this will speed their use of the teletype.

D. Calculation of the Untagged Bass Population

When the student has sampled 5 stations with fairly uniform recoveries, he can either perform the calculations or have the machine do them..

After all the samples have been calculated, the student should average those samples he feels to be representative of the pond as a whole. Since we assume that each fish is immediately returned to the pond after examination, it is possible that a sample might count the same fish several times; thus, the sample might not reflect the make-up of the entire population. In general, representative samples will show fairly good agreement for total population, if adequate time has been allowed for complete mixing of the tagged fish. The student determines the untagged population by subtracting the number of tagged fish from the average of the total population calculations (representative samples only).

NOTE: *TAG* assumes the untagged population remains constant at 424. This information is withheld, as it would not be available in a real-life situation.

V. SAMPLE RUNS OF *TAG*

RUN 1 -- POOR STUDENT STRATEGY

```
DO YOU REQUIRE INSTRUCTIONS (1=YES, 0=NO) ?1


     THE OBJECT IS TO DETERMINE THE NUMBER OF BASS
IN THE POND SHOWN IN YOUR LAB GUIDE. THE TECHNIQUE
CALLS ON YOU TO INTRODUCE TAGGED FISH INTO THE POND
AND, AT SOME LATER DATE, SAMPLE THE POND'S FISH
TO DETERMINE THE PERCENTAGE OF FISH THAT ARE TAGGED.
     YOU ARE ALLOWED ONLY 20 SAMPLES, SO CHOOSE CAREFULLY.

HOW MANY TAGGED BASS DO YOU WANT FROM THE HATCHERY ?80

HOW MANY DAYS, AFTER RELEASE OF THE BASS
FROM THE CENTER OF THE POND, DO YOU WANT TO SAMPLE ?10
AT WHAT SITE DO YOU WANT TO SAMPLE FIRST
(REFER TO MAP IN STUDENT MANUAL FOR X AND Y COORDINATES.
ENTER AS X,Y) ?0,0
HOW MANY FISH ?100
 SAMPLE:  1
STATION:  0 , 0      DAY:  10
 TAGGED:  26     UNTAGGED:  74


ANOTHER SAMPLE ON DAY  10  (1=YES, 0=NO) ?1

SITE COORDINATES ?35,-35
HOW MANY FISH ?100
 SAMPLE:  2
STATION:  35 ,-35      DAY:  10
 TAGGED:  19     UNTAGGED:  81


ANOTHER SAMPLE ON DAY  10 ?1

SITE COORDINATES ?-70,-5
HOW MANY FISH ?100
 SAMPLE:  3
STATION: -70 ,-5       DAY:  10
 TAGGED:  11     UNTAGGED:  89
```

DAY 10 SAMPLES INDICATE THAT THE TAGGED FISH ARE STILL LARGELY CLUSTERED IN THE CENTER OF THE POND.

```
ANOTHER SAMPLE ON DAY  10 ?1

SITE COORDINATES ?-40,12
HOW MANY FISH ?100
 SAMPLE:  4
STATION: -40 , 12      DAY:  10
 TAGGED:  20     UNTAGGED:  80


ANOTHER SAMPLE ON DAY  10 ?0

DO YOU WANT TO SAMPLE ON ANOTHER DAY (1=YES, 0=NO) ?1
WHAT DAY NUMBER ?20
```

THE STUDENT HAS ELECTED TO CONTINUE HIS SAMPLING ON DAY 20.

```
AT WHAT SITE DO YOU WANT TO SAMPLE FIRST ?0,0
HOW MANY FISH ?100
 SAMPLE:  5
STATION:  0 , 0      DAY:  20
 TAGGED:  16     UNTAGGED:  84


ANOTHER SAMPLE ON DAY  20 ?1

SITE COORDINATES ?35,-35
HOW MANY FISH ?100
 SAMPLE:  6
STATION:  35 ,-35     DAY:  20
 TAGGED:  11     UNTAGGED:  89
```

ON DAY 20, THE SAMPLING SITES NEAR THE CENTER OF THE POND (SUCH AS 0,0) INDICATE A HIGHER CONCENTRATION OF TAGGED FISH. THEREFORE, THE TAGGED FISH ARE STILL NOT RANDOMLY DISTRIBUTED.

```
ANOTHER SAMPLE ON DAY  20 ?1

SITE COORDINATES ?-70,5
HOW MANY FISH ?100
 SAMPLE:  7
STATION: -70 , 5      DAY:  20
 TAGGED:  13     UNTAGGED:  87
```

```
ANOTHER SAM..E ON DAY  2. ?1

SITE COORDINATES ?-40,12
HOW MANY FISH ?100
 SAMPLE:  8
STATION: -40 , 12      DAY:  20
 TAGGED:  15     UNTAGGED:  85


ANOTHER SAMPLE ON DAY  20 ?6

DO YOU WANT TO SAMPLE ON ANOTHER DAY ?0
```

IN SPITE OF THE POOR DISTRIBUTION, THE STUDENT HAS STOPPED SAMPLING BY REPLYING TO THESE QUESTIONS WITH 0.

```
IF YOU HAVE SELECTED YOUR SAMPLES CAREFULLY
YOU SHOULD BE ABLE TO DETERMINE THE TOTAL
BASS POPULATION OF THE LAKE.

  YOU CAN USE THE FORMULA:
                (TOTAL TAGGED FISH IN POND) X (SAMPLE SIZE)
  TOTAL POP.= ---------------------------------------------
                (NUMBER OF TAGGED FISH RECOVERED AT SITE)

DO YOU WISH TO DO THE CALCULATIONS YOURSELF(1=YES, 0=NO) ?0

WHICH SAMPLE DO YOU WISH TO EVALUATE FIRST (SAMPLE NUMBER) ?5

          80   X   100
        ---------------- =  500
             16


ANOTHER CALCULATION (1=YES,0=NO) ?1

 (SAMPLE NUMBER) ?6

          80   X   100
        ---------------- =  727
             11
```

THE PROGRAM WILL CALCULATE THE TOTAL BASS POPULATION USING THE ABOVE FORMULA.

```
ANOTHER CALCULATION (1=YES,0=NO) ?1

 (SAMPLE NUMBER) ?7

          80   X   100
        ---------------- =  615
              13

ANOTHER CALCULATION (1=YES,0=NO) ?1

 (SAMPLE NUMBER) ?8

          80   X   100
        ---------------- =  533
              15

ANOTHER CALCULATION (1=YES,0=NO) ?0

ENTER YOUR ESTIMATE OF THE UNTAGGED BASS POPULATION ?514
```

THE STUDENT'S ESTIMATE IS AN AVERAGE OF THE TOTAL POPULATION FROM HIS DAY 2Ø SAMPLES MINUS THE NUMBER OF TAGGED FISH.

**YOUR ESTIMATE IS CLOSE, BUT NOT WITHIN 10 PERCENT
OF THE ACTUAL POPULATION.
EXAMINE YOUR SAMPLING STATEGY AND TRY AGAIN.**

RUN 2 -- IMPROVED STUDENT STRATEGY

```
DO YOU REQUIRE INSTRUCTIONS (1=YES, 0=NO) ?0

HOW MANY TAGGED BASS DO YOU WANT FROM THE HATCHERY ?100

HOW MANY DAYS, AFTER RELEASE OF THE BASS
FROM THE CENTER OF THE POND, DO YOU WANT TO SAMPLE ?40

AT WHAT SITE DO YOU WANT TO SAMPLE FIRST
(REFER TO MAP IN STUDENT MANUAL FOR X AND Y COORDINATES.
ENTER AS X,Y) ?0,0
HOW MANY FISH ?100
 SAMPLE:   1
STATION:   0 , 0      DAY:   40
 TAGGED:   19     UNTAGGED:   81

ANOTHER SAMPLE ON DAY  40  (1=YES, 0=NO) ?1

SITE COORDINATES ?35,-35
HOW MANY FISH ?100
 SAMPLE:   2
STATION:   35 ,-35     DAY:   40
 TAGGED:   20     UNTAGGED:   80

ANOTHER SAMPLE ON DAY  40 ?1

SITE COORDINATES ?-70,-5
HOW MANY FISH ?100
 SAMPLE:   3
STATION:  -70 ,-5      DAY:   40
 TAGGED:   17     UNTAGGED:   83

ANOTHER SAMPLE ON DAY  40 ?1

SITE COORDINATES ?-40,12
HOW MANY FISH ?100
 SAMPLE:   4
STATION:  -40 , 12     DAY:   40
 TAGGED:   18     UNTAGGED:   82
```

BY DAY 40 THE BASS HAVE HAD ADEQUATE TIME TO DISTRIBUTE THEMSELVES THROUGHOUT THE POPULATION.

NOTE THE FAIRLY UNIFORM SAMPLES FROM ALL AREAS OF THE POND.

28

```
ANOTHER SAMPLE ON DAY  40 ?1

SITE COORDINATES ?10,60
HOW MANY FISH ?100
 SAMPLE:  5
STATION:  10 , 60      DAY:  40
 TAGGED:  21     UNTAGGED:  79


ANOTHER SAMPLE ON DAY  40 ?0

DO YOU WANT TO SAMPLE ON ANOTHER DAY (1=YES, 0=NO) ?0


IF YOU HAVE SELECTED YOUR SAMPLES CAREFULLY
YOU SHOULD BE ABLE TO DETERMINE THE TOTAL
BASS POPULATION OF THE POND.

  YOU CAN USE THE FORMULA:
                (TOTAL TAGGED FISH IN POND) X (SAMPLE SIZE)
  TOTAL POP.= ----------------------------------------------
                 (NUMBER OF TAGGED FISH RECOVERED AT SITE)

DO YOU WISH TO DO THE CALCULATIONS YOURSELF(1=YES, 0=NO) ?0

WHICH SAMPLE DO YOU WISH TO EVALUATE FIRST (SAMPLE NUMBER) ?1

          100   X   100
         ---------------- =  526
               19


ANOTHER CALCULATION (1=YES,0=NO) ?1

 (SAMPLE NUMBER) ?2

          100   X   100
         ---------------- =  500
               20


ANOTHER CALCULATION (1=YES,0=NO) ?1

 (SAMPLE NUMBER) ?3

          100   X   100
         ---------------- =  588
               17
```

```
ANOTHER CALCULATION (1=YES,0=NO) ?1

 (SAMPLE NUMBER) ?4

          100   X   100
        ---------------- =  555
              18

ANOTHER CALCULATION (1=YES,0=NO) ?1

 (SAMPLE NUMBER) ?5

          100   X   100
        ---------------- =  476
              21


ANOTHER CALCULATION (1=YES,0=NO) ?0

ENTER YOUR ESTIMATE OF THE UNTAGGED BASS POPULATION ?429

YOUR ESTIMATE IS GOOD.  CONGRATULATIONS.
```

VI. PLAN FOR USING *TAG*

A. Preparation Activities. This unit might be introduced in the following manner:

1) Define what is meant by a wildlife population; that is, wildlife population is the total number of animals of a certain species in a given region.

2) Conduct a general discussion of the problem of determining the size of a wildlife population. Introduce the idea of direct counting versus sampling.

3) Have the students work the bean-seed exercise in the *STUDENT MANUAL*. A key to the exercise questions is given below. This exercise should act as an excellent introduction to sampling techniques.

4) After the bean-seed exercise is completed, conduct a discussion on the analogy between that exercise and the fish problem. Comments regarding this analogy are included in the key below. The students should now be in a good position to begin the program.

5) If students have an inadequate background in graphical skills, review technique for determining X and Y coordinates using the pond map from the *STUDENT MANUAL*.

B. Use of the Program

TAG is probably best suited to individual use or small group use (2 - 3 students); however, with careful preparation *TAG* can be used with groups of any size.

Students should be asked to give reasons for choosing certain sample sizes, recovery sites, and so forth; however, they may not have clear answers until they have used *TAG* to discover good tagging and sampling combinations.

C. Answer Key to Questions in the *STUDENT MANUAL* for the Bean-Seed Problem:

Fill a pint container approximately one-half full of bean seeds.

1) DEVISE AS MANY WAYS AS YOU CAN FOR ESTIMATING THE NUMBER OF BEAN SEEDS IN THE CONTAINER. FOR EACH METHOD THAT YOU DEVISE, COMPUTE AN ESTIMATE OF THE NUMBER OF BEAN SEEDS IN THE CONTAINER.

One method might be to calculate the volume of the container and the volume of one seed, then

$$\text{number of seeds} = \frac{\text{volume of container}}{\text{volume per seed}}$$

2) *DO YOU THINK THAT ANY OF THE METHODS WHICH YOU USED IN (1) COULD BE USED TO ESTIMATE THE FISH POPULATION IN A FARM POND WITHOUT ALTERING THE ECOLOGY OF THE POND? EXPLAIN.*

See the answer to (1). It might be possible to estimate the volume required by a single fish. Obviously, direct counting would alter the pond's ecology.

3) *COVER YOUR EYES AND DRAW OUT 20 BEAN SEEDS FROM THE CONTAINER. USE THE PROPORTIONS FORMULA Q/P = M/N GIVEN ON PAGE 2 TO ESTIMATE THE TOTAL BEAN-SEED POPULATION IN THE CONTAINER. (BEFORE YOU CAN DO THIS, YOU WILL NEED TO DEFINE P, Q, N, AND M FOR THIS PROBLEM.)*

The proportions formula can be used after the student recognizes that

P = total number of bean seeds
Q = number of marked bean seeds
M = number of marked beans in sample
N = sample size

The analogy to the fish population problem is that the total number of fish (P) is analogous to the total number of bean seeds (P) and so forth.

4) *REPEAT THE PROCEDURE IN (3) THREE MORE TIMES; THEN FIND AN AVERAGE OF THE FOUR ESTIMATED VALUES FOR P.*

This is a straightforward exercise. Assume that 20 marked bean seeds are put into the container and 4 samples of 10 beans each are taken from the container. The following data might occur:

Sample (N = 10)	Total Number of Marked Beans (Q)	Marked Beans in Sample (M)	Population (P)
1	20	2	100
2	20	1	200
3	20	2	100
4	20	3	67

Average population estimate =

$$\frac{100 + 200 + 100 + 67}{4} = 116 \text{ bean seeds.}$$

5) *NOW REPEAT THE PROCEDURE DESCRIBED IN (3) WITH THE FOLLOWING CHANGE: AFTER THE FIRST BEAN SEED IS DRAWN FROM THE CONTAINER, RECORD WHETHER OR NOT IT IS MARKED, THEN RETURN IT TO THE CONTAINER AND SHAKE THE CONTAINER WELL. REPEAT THIS PROCESS UNTIL THE RESULTS OF 15 DRAWINGS HAVE BEEN RECORDED. NOW USE THE FORMULA TO DETERMINE THE BEAN-SEED POPULATION OF THE CONTAINER.*

6) *REPEAT THE PROCEDURE IN (5) THREE MORE TIMES: THEN FIND AN AVERAGE OF THE FOUR VALUES FOR P.*

This sampling procedure differs from (3) only in the returning of the bean seed to the total population after each drawing. This is an excellent sampling procedure. The fish sampling in *TAG* is done in this manner.

7) *NOW COUNT THE NUMBER OF BEANS IN THE CONTAINER. WHICH POPULATION ESTIMATE WAS THE MOST ACCURATE?*

Probably number (6) was the best. Numbers (3) and (5) are point estimates and it is very probable that they will be less accurate than the average estimates in (4) and in (6).

8) *IN VIEW OF YOUR ANSWERS TO (3), (4), (5), AND (6), DISCUSS EACH OF THE FOLLOWING QUESTIONS:*

a) *DO YOU THINK THE RESULTS WOULD HAVE BEEN DIFFERENT IF THE NUMBER OF MARKED BEANS HAD BEEN LARGER? SMALLER?*

The results would have been significantly different only if the number of marked beans put into the container were very small or very large compared to the number of unmarked beans.

b) *COMPARE YOUR RESULTS WITH THOSE OF ONE OF YOUR CLASSMATES WHO USED A CONTAINER WITH A DIFFERENT SHAPE. HOW DO YOU THINK THE SHAPE OF YOUR CONTAINER MIGHT HAVE AFFECTED YOUR RESULTS?*

Tagging and recovery calls for random sampling of the population after the diffusion process has resulted in the marked individuals (either beans or fish) being evenly distributed. Any container that either restricts mixing or that limits sampling to a very small part of the total population may adversely affect the student's results.

c) *SUPPOSE YOU HAD EMPTIED THE BEANS INTO A CONTAINER WITH A SURFACE AREA SUCH AS A PIE TIN. HOW WOULD YOU HAVE ALTERED YOUR TECHNIQUE FOR DRAWING OUT BEANS AND SHAKING THE CONTAINER? WHY? DO YOU THINK YOUR REASONING WILL APPLY TO THE FARM POND PROBLEM? DISCUSS.*

All the beans will be exposed for sampling. Since tagging and recovery requires a random sample, beans should be selected from all areas of the pie tin. The pond in *TAG* is similar to the pie tin in that both the pan and the pond are shallow and the population is spread thinly over the entire area.

d) *IF YOU HAD DROPPED YOUR CONTAINER OF BEANS AND IN THE RECOVERY OF THEM MISSED A FEW, HOW GREAT AN EFFECT DO YOU THINK THIS WOULD HAVE ON YOUR RESULTS? CAN YOU SEE A POSSIBLE COMPARISON BETWEEN THIS SITUATION AND THE MORTALITY RATE FOR TAGGED FISH IN THE FARM POND? DISCUSS.*

The loss of a few beans would cause little error; this corresponds to mortality among the bass. The program contains a mortality factor (C), but it has little effect during the usual sampling time.

e) *A FACTOR WHICH DOES NOT ENTER INTO THE BEAN PROBLEM BUT WHICH IS BASIC TO THE FARM-POND PROBLEM IS THE FACTOR OF TIME. DISCUSS.*

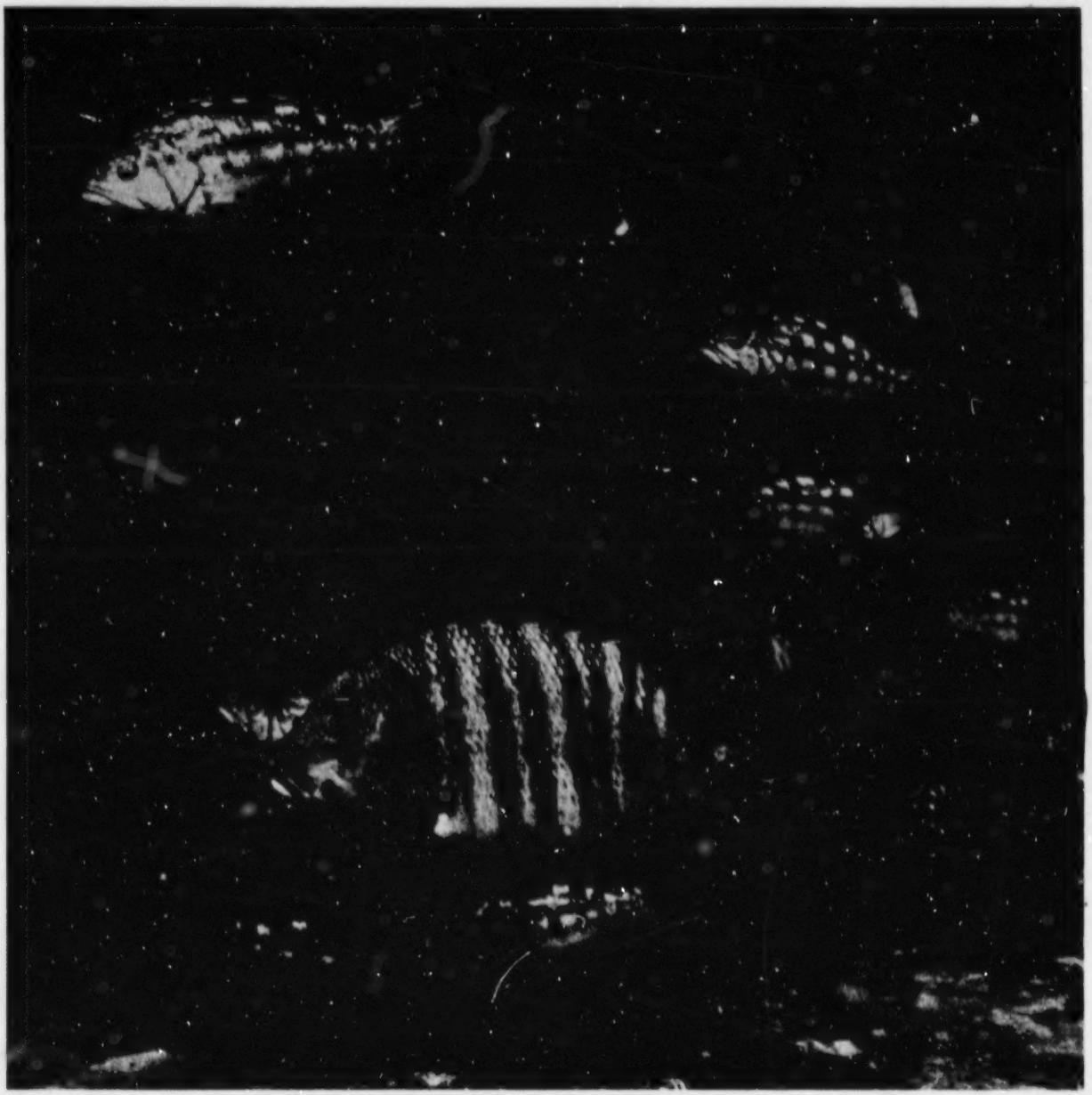
Time is an important factor because it takes time for the fish to mix -- about 15 days for total mixing to occur. After that, time is not a factor. The exception occurs for very long times, since then mortality has an important effect.

DIGITAL EQUIPMENT CORPORATION

RESOURCE HANDBOOK $.50

education

HUNTINGTON II Simulation Program - TAG



computers are for kids — digital — EduSystems—expandable, economical

DEC EDUCATIONAL PUBLICATIONS

A partial list of the publications in the continuing series of curriculum material published by DEC for use with EduSystems and RSTS are listed below. Please inquire directly for prices on classroom quantities.

Additional publications may be obtained from:

Software Distribution Center
Digital Equipment Corporation
Maynard, Massachusetts 01754

Popolution: Self-teaching BASIC Workbook	$2.00
BASIC Matrix Operations	$1.00
Computer-Augmented Calculus Topics	$1.50
Problems For Computer Mathematics	$1.25
Advanced Problems For Computer Mathematics	$2.00
BASIC Application Programs	
Mathematics I	$1.00
Mathematics II	1.00
Science	1.00
Business and Social Studies	1.00
Plotting	1.00
Huntington I Application Programs	
MATHEMATICS	$2.00
TEACHER ASSISTANCE	1.00
Huntington I Simulation Programs	
BIOLOGY	$1.00
CHEMISTRY	2.00
EARTH SCIENCE	1.00
PHYSICS	2.00
SOCIAL STUDIES	1.00
Huntington II Simulation Modules	
Student Workbook	$0.30
Teacher's Guide	.30
Resource Handbook	.50
Program Paper Tape	1.00

RESOURCE
MANUAL

TAG

"TAGGING AND RECOVERY" METHOD
FOR WILDLIFE POPULATION STUDY

Developed By:

James Friedland
General Douglas MacArthur High School
Levittown, New York

Programmed By:

James Friedland
Stuart Hollander,
State University of New York
Stony Brook, New York

Support Material By:

James Friedland
Granville J. Smith, II
Northwest Regional Educational Lab
Portland, Oregon

HUNTINGTON TWO COMPUTER PROJECT

Copyright © 1973, State University of New York

14 May 1973

The work of the Huntington Two Computer Project is partially supported by the National Science Foundation, Grant GW-5883.

TAG

RESOURCE MANUAL

Table of Contents

I. Background Materials for *TAG* Program 1

II. Suggested Projects 3

III. Further Instructional Uses for the Program 4

IV. Description of the Model Used 5

V. *TAG* Program Listing 10

VI. Additional Exercises Using *TAG* 13

VII. Bibliography 15

I. BACKGROUND MATERIALS FOR *TAG* PROGRAM

Man needs knowledge about wildlife in order to ensure its continued existence. Our destruction of natural habitats in the search of energy and raw materials, as well as living space, has threatened the existence of many species.

Before we can do anything significant to aid or protect a particular species, we need to know certain things about the species and its environment. One thing in particular that we need to know about the species is the size of its population in a given area.

Determining the size of a wildlife population is hardly ever an easy job. It is easier to do with some populations than with others, and the task is simplified when the population inhabits an area with natural boundaries, since the location of all the members of the population can be clearly determined.

One such self-contained area is a small lake or farm pond. In such a pond it might be possible to count all of the individual fish of one species (e.g., bass) by some method such as draining the pond or removing all of the fish. Either of these methods would, however, drastically alter the ecology of the pond and threaten the existence of the bass we are trying to aid!

The problem of counting the fish in a farm pond requires some other solution. One solution lies in the use of *sampling* techniques and *statistical estimates*. Proper sampling and proper treatment of sampling results can provide us with a good estimate of the size of any wildlife population.

Tagging and Estimating

One method used to estimate the number of individuals in any area calls for taking a known number of individuals, marking them for later identification, and then setting them free in the area to be studied. At a later date, when complete mixing of the marked individuals with the rest of the population has occurred, a small sample is taken from the area and a comparison of the number of marked individuals with unmarked individuals is made in order to obtain an estimate of the total population size. Suppose, for example, that 1000 marked fish are released in a pond and that 50 fish are caught later, with 10 of these marked and 40 of them unmarked; then the entire population may be estimated to be 5000 fish. (*REASONING*: 1 fish of every 5 in the sample was marked; if 1000 marked fish were released and if, indeed, 1 fish of every 5 in the total population is marked as our sample indicates -- then there must be a total of 5000 fish in the pond.)

We must remember that sampling is always subject to error and that only careful planning will help us to keep this error small. Our sampling will be in error if we do not allow enough time to pass before sampling, in order to allow the marked fish to swim to all parts of the pond and to mix completely with the other fish. Another point to consider is that some areas of the pond may not provide as much cover or food for the fish, so that fish will seldom swim into those areas, and those areas will remain "under-represented" in terms of population.

By choosing a number of sites for sampling and allowing an adequate amount of time for migration to these sites, we can get better estimates of population size.

Something else that you will want to consider is the number of tagged fish required to provide a good estimate of the total population. Obviously, the more tagged fish released, the greater the change in the ecology of the pond as well as in the cost of the study. *THIS MEANS THAT YOU WILL WANT TO DETERMINE THE LEAST NUMBER OF TAGGED FISH REQUIRED FOR A GOOD ESTIMATE OF THE TOTAL NUMBER OF FISH IN THE POND.*

II. SUGGESTED PROJECTS

A. Take a field trip to a local farm pond (*TAG* simulates a 5-acre pond). On this trip, teams of students could be assigned different areas of study such as the following:

1) feasibility of counting the total fish population by draining the pond or removing all the fish;

2) environmental influences on the pond ecology such as pollutants draining into the pond; leaching from rich mineral ore deposits in the area; immigration or introduction of new aquatic life species, both plant and animal (this may require several student teams);

3) pond shape and depth as a help or hindrance to actual diffusion of the fish being studied; also, a study of the best sampling site.

B. Take a field trip to a fish hatchery for the purpose of learning about fish-tagging methods and problems, different sampling techniques and the problems encountered in introducing fish from a hatchery into a new site such as the pond simulated in *TAG*.

C. Organize a group of students to make a study of the living environments, migrating habits, age, and health of certain species, as well as the problems encountered and results obtained by other groups or agencies in trying to sample or otherwise study these species. Such species could include the salmon, western elk, fox, rabbit, starling, some water fowl, or various insects.

D. Take a field trip to visit the offices of the fish and game commission to study, among other things, the role population counting plays in establishing the dates of the hunting and fishing seasons, and the duration of the seasons, as well as other control measures.

III. FURTHER INSTRUCTIONAL USES FOR THE PROGRAM

A. As with most simulation programs, a good supplementary exercise for students would be to examine the model which underlies the program to determine what changes or extensions could be made. Comparisons may be made between results obtained with the present model and those obtained with the new model.

B. The constants used in the present model can be changed easily (see Section IV. G for details). Experimentation with other values could be carried out, and the results compared with those obtained using the original values.

C. In addition to its obvious use in a biology classroom, *TAG* can be used by the mathematics teacher to introduce his students to the concept of proportion and to provide the students with practice in solving realistic proportion problems. (These exercises might also be used to provide students with experience in constructing a graph from a data sheet.) The more capable math students might wish to study in detail the equations given in Section IV of this *RESOURCE MANUAL* entitled, "DESCRIPTION OF THE MODEL USED."

D. The advanced student with a knowledge of computer programming could develop a more sophisticated model which not only would have a larger pond with more fish, but also a larger number of sites and a greater variation in site characteristics. Site characteristics could reflect accumulated data concerning the effects of pollution.*

E. Project work -- see Section VI of this manual.

*See the program *POLUT* for possible model of pollution effect.

IV. DESCRIPTION OF THE MODEL USED

A. Source of the Model

The model which is used in the *TAG* computer program is based on data from the New York State Conservation Department and Cornell University's Department of Conservation, and represents their experience with work of this kind.

B. Variables

The following variables are used in the *TAG* program. The numbers in parentheses are the values presently assigned to each variable. These variables can be altered according to the directions given in Part G of this Section.

Variable	Meaning
A	Area of the pond in square meters
A1	Area of diffusion of tagged fish
B	Bell-shaped randomizer
C	Probability of a tagged fish surviving 1 day (0.998)
C1	Probability of catching a tagged fish after its arrival at sampling location
D	Diffusion constant
E	Day of last sample (initially zero)
M	Number of tagged fish in sample Z
N	Total number of fish sampled in sample Z
P	Population of untagged fish in pond (424)
P1	Number of tagged fish placed in pond
P3	Actual number of tagged fish

Q	Response holder
R	Radius of pond in meters (75)
R1	Radius to sample site from center of diffusion
T	Day number
S	Density of tagged fish at site X, Y
X	X-coordinate of sampling site
Y	Y-coordinate of sampling site
Z	Sample number
Z9	Density of population that has reached edge of pond during time T.

C. Calculation of Diffusion through Pond

The density of tagged fish at any site is a function of the radius of that site from the center of diffusion (R1) and the length of time diffusion has been going on (T) as well as the number of tagged fish surviving at time T (P3).

1) Density of tagged fish

$$S = Z9 + \frac{\{\exp[-(R1-2.5)^2/(D*T)] - \exp[-(R1+2.5)^2/(D*T)]\} * P3}{3.14 * [(R1+2.5)^2 - (R1-2.5)^2]}$$

2) Population of tagged fish

$$P3 = C^T * P1$$

D. Calculated Probability of Catching Tagged Fish

The program checks first to determine if the tagged fish could have arrived at the sampling station. If not, the probability is set to zero. If the fish have arrived, the following formula is used:

$$C1 = \frac{S}{(S + P/A)}$$

E. Calculated Number of Tagged Fish Caught

The number of tagged fish caught is calculated by the following formula:

$$M = N * C1 + B * \sqrt{(C1 - C1^2) * N}$$

where $B * \sqrt{(C1 - C1^2) * N}$ is a measure of randomness.

The number of tagged fish actually used in the program is this value of M converted to an integer value by rounding up (i.e., by adding 0.5 and then ignoring the fractional part).

NOTE: Symbol (*) denotes multiplication.

F. Assumptions under Which the Model Operates

1) It is assumed that after each fish is caught and examined, it is returned to the pond.

2) The farm pond is essentially circular and has a total area of approximately 17,660 square meters (about 5 acres).

3) The untagged population of fish in the farm pond remains constant at 424. To alter this number for different class groups, see Section G below.

4) Introduction of tagged fish causes no great disturbance in the ecology of the farm pond. (This might not be true if large numbers of tagged fish were introduced.)

5) The small mortality rate (low death rate) of the tagged fish has a small effect on their rate of diffusion.

G. Altering the Model

1) Certain parameters used in the *TAG* model are quite easy to change. These are listed below:

Variable	Meaning
C	Probability of a tagged fish surviving 1 day (where 1 = 100%)

D	Diffusion constant (a larger D will cause faster diffusion of tagged fish)
P	Population of untagged fish in pond
R	Radius of pond in meters

The values for these variables are stored in a data statement, line 23Ø of the program, in the following order:

P, R, E, D, C

Currently, this data statement reads as follows:

```
23Ø  DATA  424,   75,   Ø,   5ØØ,   .998
           ↑      ↑     ↑     ↑      ↑
           P      R     E     D      C
```

In order to change one of the values, line 23Ø in the program must be re-typed, with the new value for a variable entered in the appropriate place. For example, to change the diffusion constant for the fish from 500 to 210 and the pond size from 75-meter radius to 100-meter radius, enter the following line after the program is called, but before the computer is instructed to run:

```
23Ø  DATA  424,   1ØØ,    Ø,   21Ø,    .998
                  ↑              ↑
           (R is changed)  (D is changed)
```

Notice that the values for the unchanged variables are typed in exactly as they were before. The computer will now use the new values which have been entered when it is instructed to run the program.

2) Elimination of computer calculation for total population size. Line 64Ø currently reads

64Ø PRINT

Re-type this line as

64Ø STOP

This modification will eliminate both the calculation and evaluation features from the program.

3) Decreasing the computer storage required by *TAG*.

a) In order to accommodate users who are limited by the memory available on their machines, the paper-tape copy of *TAG* is arranged to permit the loading of the program without REM statements and student instructions. All REM statements are included in the first part of the tape and are separated from the main body of the program by a section of tape with just leader holes punched. In order to load the reduced-size program, it is necessary only to start the program tape near the middle of the second section of leader holes.

b) Elimination of calculation and evaluation sections. Depending on the particular version of BASIC being used, this can be done by typing

DELETE 645, 825 or DELETE 645-845

after the tape has been loaded.

With BASIC versions lacking the DELETE command, these lines can be deleted by typing the appropriate line number and then hitting the return key for each line.

The combined deletions described in (a) and (b) above decrease the length of *TAG* from 166 lines (about 3800 characters) to 86 lines (about 2200 characters).

4) Changing maximum number of samples allowed

a) Line 215 currently reads:

215 DIMN(20), M(20)

Replace 20 with the maximum sample number.

b) Line 420 currently reads:

420 IF Z = 21 THEN 585

Replace 21 with maximum number plus one.

c) Change text in lines 205, 585.

Machines with limited memory may not accept larger maximum number of samples.

V. *TAG* PROGRAM LISTING

```
100 REM - TAG: A SURVEY OF BASS POPULATION IN A SIMULATED FARM
105 REM POND USING TAGGING AND RECOVERY.
110 REM COPYRIGHT 1972,1973 -STATE UNIVERSITY OF NEW YORK
115 REM MODEL AND PROGRAM DESIGN: J. FRIEDLAND
120 REM LATEST REVISION: 7/20/73
125 REM P=POP. OF BASS:P1=POP. OF TAGGED BASS
130 REM R=RADIUS OF POND:R1=RADIUS OF SAMPLE SITE
135 REM A=AREA OF POND:T=DAY NUMBER
140 REM D=DIFFUSION FACTOR:C=CHANCE OF TAGGED BASS SURVIVAL/DAY
145 REM C1=CHANCE OF CATCHING A TAGGED BASS VS. AN UNTAGGED BASS
150 PRINT"DO YOU REQUIRE INSTRUCTIONS (1=YES, 0=NO)";
155 INPUTQ
160 IFQ=0THEN210
165 IFQ<>1THEN155
170 PRINT
175 PRINT
180 PRINT"     THE OBJECT IS TO DETERMINE THE NUMBER OF BASS"
185 PRINT"IN THE POND SHOWN IN YOUR LAB GUIDE. THE TECHNIQUE"
190 PRINT"CALLS ON YOU TO INTRODUCE TAGGED FISH INTO THE POND"
195 PRINT"AND, AT SOME LATER DATE, SAMPLE THE POND'S FISH"
200 PRINT"TO DETERMINE THE PERCENTAGE OF FISH THAT ARE TAGGED."
205 PRINT"     YOU ARE ALLOWED ONLY 20 SAMPLES, SO CHOOSE CAREFULLY."
210 PRINT
215 DIMN(20),M(20)
220 LETZ=0
225 READP,R,E,D,C
230 DATA424,75,0,500,.998
235 RANDOMIZE
240 LETA=3.14*R↑2
245 PRINT"HOW MANY TAGGED BASS DO YOU WANT FROM THE HATCHERY";
250 INPUTP1
255 IFP1<=400THEN270
260 PRINT"SORRY, MAXIMUM NUMBER OF FISH AVAILABLE IS 400"
265 GOTO245
270 PRINT
275 PRINT"HOW MANY DAYS, AFTER RELEASE OF THE BASS"
280 PRINT"FROM THE CENTER OF THE POND, DO YOU WANT TO SAMPLE";
285 INPUTT
290 IFT>ETHEN310
295 PRINT
300 PRINT"DAY ";T;" HAS PASSED"
305 GOTO275
310 PRINT
315 LETP3=C↑T*P1
320 LETZ9=EXP(-(R↑2/(D*T)))*P3/A
325 PRINT"AT WHAT SITE DO YOU WANT TO SAMPLE FIRST";
330 IFE<>0THEN350
335 PRINT
340 PRINT"(REFER TO MAP IN STUDENT MANUAL FOR X AND Y COORDINATES."
345 PRINT"ENTER AS X,Y)";
350 INPUTX,Y
```

```
355 LETR1=SQR(X↑2+Y↑2)
360 IFR1>.1THEN370
365 LETR1=.1
370 IFR1<=RTHEN390
375 PRINT
380 PRINT"SAMPLE SITE BEYOND SHORES OF POND"
385 GOTO340
390 LETS=EXP(-(R1-2.5)↑2/(D*T))-EXP(-(R1+2.5)↑2/(D*T))
395 LETS=(S*P3)/(3.14*((R1+2.5)↑2-(R1-2.5)↑2))+Z9
400 LETC1=S/(S+P/A)
405 IFC1>1E-10THEN415
410 LETC1=0
415 LETZ=Z+1
420 IFZ=21THEN585
425 PRINT"HOW MANY FISH";
430 INPUTN(Z)
435 LETN(Z)=INT(N(Z))
440 IFN(Z)<=400THEN455
445 LETN(Z)=INT(200*RND(0)+200)
450 PRINT"IT WAS POSSIBLE TO CATCH ONLY ";N(Z);" FISH."
455 LETB=COS(6.283*RND(0))*SQR(-2*LOG(RND(0)))
460 LETM(Z)=INT(C1*N(Z)+B*SQR((C1-C1↑2)*N(Z))+.5)
465 IFM(Z)*(N(Z)-M(Z))<0THEN455
470 PRINT" SAMPLE: ";Z
475 PRINT"STATION: ";X;",";Y;"    DAY: ";T
480 PRINT" TAGGED: ";M(Z);"   UNTAGGED: ";N(Z)-M(Z)
485 PRINT
490 PRINT
495 PRINT"ANOTHER SAMPLE ON DAY ";T;
500 IFZ>1THEN510
505 PRINT" (1=YES, 0=NO)";
510 INPUTQ
515 PRINT
520 IFQ<>1THEN535
525 PRINT"SITE COORDINATES";
530 GOTO350
535 IFQ<>0THEN505
540 PRINT"DO YOU WANT TO SAMPLE ON ANOTHER DAY";
545 IFE<>0THEN555
550 PRINT" (1=YES, 0=NO)";
555 INPUTQ
560 IFQ=0THEN590
565 IFQ<>1THEN550
570 PRINT"WHAT DAY NUMBER";
575 LETE=T
580 GOTO285
585 PRINT"YOU MAY TAKE A MAXIMUM OF 20 SAMPLES"
590 PRINT
595 PRINT
```

```
630 PRINT"IF YOU HAVE SELECTED YOUR SAMPLES CAREFULLY"
635 PRINT"YOU SHOULD BE ABLE TO DETERMINE THE TOTAL"
640 PRINT"BASS POPULATION OF THE POND."
645 PRINT
650 PRINT"  YOU CAN USE THE FORMULA:"
655 PRINT"                (TOTAL TAGGED FISH IN POND) X (SAMPLE SIZE)"
660 PRINT"  TOTAL POP.= ----------------------------------------"
665 PRINT"                 (NUMBER OF TAGGED FISH RECOVERED AT SITE)"
670 PRINT
675 PRINT"DO YOU WISH TO DO THE CALCULATIONS YOURSELF(1=YES, 0=NO)";
680 INPUTO
685 IFO<>0THEN760
690 PRINT
695 PRINT"WHICH SAMPLE DO YOU WISH TO EVALUATE FIRST";
670 PRINT" (SAMPLE NUMBER)";
675 INPUTO
680 IFO>2THEN670
685 LETO=INT(O)
690 PRINT
695 PRINT"          ";P1;"  X  ";N(O)
700 LETW=0
705 IFM(O)=0THEN715
710 LETW=INT(P1*N(O)/M(O))
715 PRINT"          ---------------- = ";W
720 PRINT"               ";M(O)
725 PRINT
730 PRINT
735 PRINT"ANOTHER CALCULATION (1=YES,0=NO)";
740 INPUTO
745 PRINT
750 IFO=1THEN670
755 IFO<>0THEN735
760 PRINT
765 PRINT"ENTER YOUR ESTIMATE OF THE UNTAGGED BASS POPULATION";
770 INPUTO
775 PRINT
780 IFABS((O-P)/P)>.1THEN795
785 PRINT"YOUR ESTIMATE IS GOOD.  CONGRATULATIONS."
790 STOP
795 IFABS(P-O)/P<=.25THEN820
800 PRINT"YOUR ESTIMATE IS NOT WITHIN 25 PERCENT"
805 PRINT"OF THE ACTUAL POPULATION."
810 PRINT"EXAMINE YOUR SAMPLING STATEGY AND TRY AGAIN."
815 STOP
820 PRINT"YOUR ESTIMATE IS CLOSE, BUT NOT WITHIN 10 PERCENT"
825 GOTO805
830 END

READY
```

VI. ADDITIONAL EXERCISES USING *TAG*

These projects have been included for the student interested in further project work.

PROJECT 1 -- Minimizing tagged population

As you know, an ecologist will always sample a population in such a way as to minimize the damage to the environment and the species being studied. Let's return to our farm pond example. There is only a certain amount of space and a certain amount of food available to the fish already present. Introducing tagged fish is certain to upset the natural balance. One solution might be to trap fish from the pond, tag them and then re-release them back into the pond.

Another solution to the problem would be to use as few fish as possible to arrive at your answer. The objective of this project is to determine the smallest number of tagged fish that will give a reliable answer at least 50% of the time.

Solving this problem will require many trials. To start you might use 100 fish for the investigation and, if that proves satisfactory, use a smaller number. Keep reducing the number of tagged fish until you get an acceptable estimate only about 50% of the time.

In your report be sure to include the strategy you used for estimating the total population.

PROJECT 2 -- Study of diffusion within a pond

In the *STUDENT MANUAL*, it was noted that the fish were released in the center of the pond. As time goes on, the fish diffuse away from the center of the pond until they are randomly mixed with the untagged population. How does this diffusion take place? A partial answer to the question can be found by sampling at the same location each day and then graphing the results, with the per cent of tagged fish in the sample on the vertical axis and days on the horizontal axis.

Try this technique for several locations in the pond. Choose as one of these location sites (Ø,Ø) -- the place where the fish were placed at the beginning of the diffusion.

PROJECT 3 -- Investigation of a larger pond

To enlarge the pond under investigation, it is necessary to alter the program *TAG*. After the program has been loaded or called and before you type "RUN", you must re-type line 230.

Currently, line 230 reads:

```
230 DATA 424,75,0,500,.998
```

The second number in the line describes the radius of the pond. You can enlarge the pond by typing a larger number in its place. For example, if you wanted to enlarge the pond to a radius of 100 meters, you would type

```
230 DATA 424,100,0,500,.998
```

Notice that everything is the same except for the second number.

After this change has been made, you are ready to begin your investigation. Here are some questions you might try to answer:

a) Does doubling the size of the pond (to 150 meters radius) double the amount of time necessary for diffusion?

b) Does doubling the size of the pond affect the accuracy of your strategy for determining total bass population?

VIII. BIBLIOGRAPHY

College Level Texts

Bardach, Ryther, and McLarney, AQUACULTURE
New York: Wiley-Interscience (1972).

Chapter 10 is specifically on Bass culture.

Frey, David G. (Ed.), LIMNOLOGY IN NORTH AMERICA
Madison: University of Wisconsin Press (1963).

Chapter 22 deals with farm ponds in North America.

Gerking, Shelby D. (Ed.), THE BIOLOGICAL BASIS OF FRESHWATER FISH PRODUCTION
New York: John Wiley and Son (1967).

Kormondy, Edward J., CONCEPTS OF ECOLOGY
Englewood Cliffs, N.J.: Prentice-Hall, Inc. (1969)

Odum, FUNDAMENTALS OF ECOLOGY, 3rd Edition
Philadelphia: W. B. Saunders Co. (1971)

Chapter 11 deals with the ecology of ponds and lakes.

Pielou, E. C., AN INTRODUCTION TO MATHEMATICAL ECOLOGY
New York: Wiley-Interscience (1969)

Chapters 7 - 12 explore laws governing and describing one-species populations.

Ricker, METHODS OF ESTIMATING VITAL STATISTICS OF FISH POPULATION
Bloomington: University of Indiana Publications

Complete analysis of sampling procedures.

Slobodkin, Lawrence B., GROWTH AND REGULATION OF ANIMAL BEHAVIOR
New York: Holt, Rinehart and Winston (1961)

A text offering many useful models for population modeling.

High School Level Texts and Books

BIOLOGICAL SCIENCE: AN INQUIRY INTO LIFE, 2nd Edition
Biological Sciences Curriculum Study
New York: Harcourt, Brace and World, Inc. (1968)
Chapters 36 and 38.

BIOLOGICAL SCIENCE: INTERACTION OF EXPERIMENTS AND IDEAS,
2nd Edition, Biological Sciences Curriculum Study
Englewood Cliffs, N.J.: Prentice-Hall Inc. (1970)
Sections 7 and 9.

BIOLOGICAL SCIENCE: MOLECULES TO MAN, Revised Edition
Biological Sciences Curriculum Study
Boston: Houghton Mifflin Company (1968)
Chapter 27.

BIOLOGY: AN APPRECIATION OF LIFE
Del Mar, California: CRM Books Inc. (1972)
Chapter 14: Population Studies.

HIGH SCHOOL BIOLOGY, 2nd Edition
Biological Sciences Curriculum Study
Chicago: Rand McNally (1969)
Chapter 2: Populations.

THE FISHES, F.D. Ommanney and the editors of Time-Life Books.
New York: Time-Life Books (1963)

Booklets

"Fish Management in New York Farm Ponds"
New York State Agricultural Extension Bulletin #1089
N.Y.S. College of Agriculture
Ithaca, New York